ONLINE MONITORING OF WATER RECYCLING FROM PALM OIL MILL EFFLEUENT (POME)

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

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Project Supervisor

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TRONOH, PERAK

December 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Muhamad Ariff bin Abd Rahim

ABSTRACT

This study will demonstrate the understanding of the chosen topic, which is **Online Monitoring Of Water Recycling From Palm Oil Mill Effluent (POME).** The discharge of poor quality effluents by the palm oil mill is posing a serious threat to water resources. As there is very few continuous monitoring system of palm oil effluent that available so there is need to extend this to other palm oil mill. The objective of the project is to develop an online monitoring of water recycling and treatment from palm oil mill effluent.

Through this study, there will be a development of online monitoring (Graphical User Interface (GUI)) using LabVIEW and Data Acquisition (DAQ) card. The parameters will be set through the software to be comparison with actual data about the quality of the water. Lab testing will be done with a model of the system for the designed system to ensure this online system will work accordingly due to desire objective.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor, Assoc Prof Dr Irraivan Elamvazuthi for the guidance and support during supervising my project from the beginning until present. He is also being very helpful when I encounters any difficulties and problems in handling my project and always encourage out me to not giving up searching the solution for such problems and difficulties.

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Apart from that, I also would like to take this opportunity to thank all my friends who have directly or indirectly aided me in completing this course. Their assistance in solving some of the problems and backup ideas has been a great relieve.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Malaysia currently is a well known country for production of palm oil in the world. Malaysia has a lot of palm oil plantation all around the country. Malaysia also owned palm oil mills that produce palm oil with extraction of crude palm oil from the fruit bunches. Palm oil productions from Malaysia are also well known for good quality and clean with high demand in the market.

Besides, the process of extraction and purification leads to some kinds of waste that generally known as palm oil mill effluent (POME). This POME basically produces wastes such as water, solids and dissolved impurities that are really harmful to the environment. Most of the wastes come out as water that really hazardous to the environment [5]. The treatment of the waste water is very important before being discharged to the environment via water resources. There is need for continuous online monitoring of recycling and treatment of the water for POME.

1.2 Problem Statement

The discharge of poor quality effluents by the palm oil mill is posing a serious threat to water resources. In order to eliminate this threat, there is some treatment for this. The process is quite hard to be monitored manually. There is a need of online monitoring of this process.

1.3 Objectives and Scope of Study

1.3.1 Objectives

The objectives of the project are:

i. To develop the online monitoring system in the industry that will be installed at the palm oil mill to monitor the water treatment process from the palm oil mill effluents.
ii. To ease the process of monitoring water treatment at the palm oil mill.

1.3.2 Scope of Study

The research and information that have been done so far rely on development of the system itself by identifying and understanding the system. All the information need to be gathered in order to develop the online monitoring system. This will ease the operator to analyze the system and at the same time monitoring the waste treatment process of the water.

The scope of this project can be defined as below:

i. Design and develop Data Acquisition (DAQ) system for water treatment control process.
ii. Develop User Interface using Laboratory Virtual Instrument Engineering Workbench (LabVIEW).

CHAPTER 2
LITERATURE REVIEW

2.1 Palm Oil Mill Effluent (POME)

Palm oil mill effluent (POME) came from two main processes which are sterilization and clarification stages, as the condensate and clarification sludge, respectively. The clarification sludge has higher level of residues compared to the sterilizer condensate. Both contain some level of unrecovered oils and fats. The final POME would of course include hydrocyclone washing and cleaning up process in the mill. Approximately water required to process 1 ton of fresh fruit bunches (FFB) are 1-1.5 tons [1]. Figure 1 show the process at the palm oil mill.

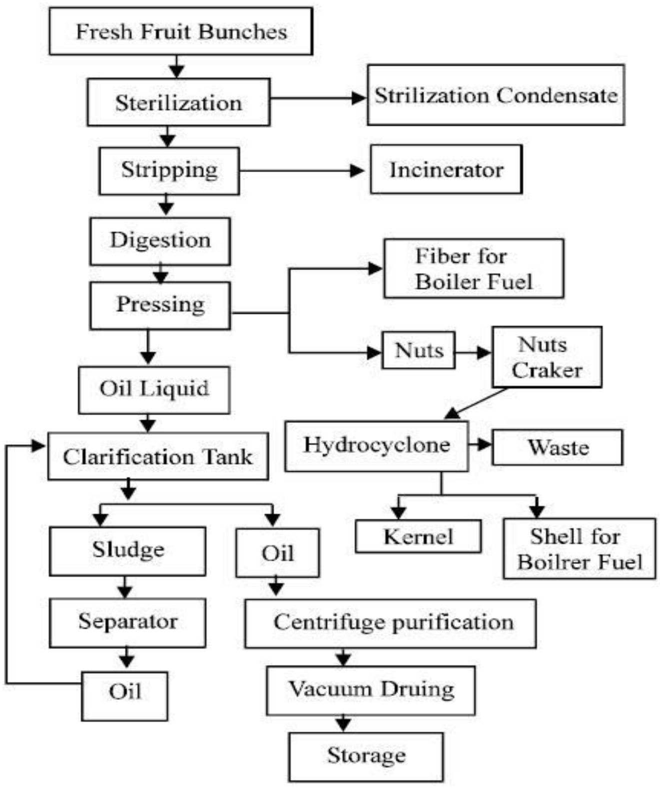

Figure 1 A block flow diagram of the palm oil mill process [4]

Generally, the characteristics of industrial effluents are given as follows:

- Soluble organics resulting in dissolved oxygen depletion in streams and estuaries and/or causing taste and odour.
- Organic suspended solids resulting in dissolved oxygen depletion.
- Inert suspended solids causing turbidity and resulting in bottom sediments.
- Toxic substances and heavy metals
- Oil and floating materials.
- Dissolved salts particularly phosphates, chlorides and nitrates [2].

2.1.1 POME Composition

Satunto [3] reported about composition from analysis of typical sample from Malaysia as below;

Water	:	95%
Oil (free)	:	1%
Suspended Solid	:	2%
Dissolved Solids	:	2%

POME is in the form of highly concentrated dark brown colloidal slurry of water, oil and fine cellulosic materials. Due to the introduction of heat (from the sterilization stage) and vigorous mechanical processes, the discharge temperature of POME is approximately 80-90 °C. The chemical properties of POME vary widely and depend on the operation and quality control of the mills [1]. Table 1 shows the properties of POME. Apart from the organic composition, POME is also reach in mineral content, particularly phosphorus (18mg/L), potassium (2270mg/L), magnesium (615 mg/L) and calcium (439 mg/L) [1].

Table 1 Properties of POME [1]

Chemical Property	Average	Range
pH	4.20	3.4-5.2
BOD (mg/L)	25000	10250-43750
COD (mg/L)	50000	15000-100000
Oil and grease (mg/L)	6000	150-18000
Ammonical nitrogen (mg/L)	35	4-80
Total nitrogen (mg/L)	750	180-1400
Suspended solid (mg/L)	18000	500-54000
Total solid (mg/L)	40000	11500-78000

2.2 Treatment Process of the Effluent Water

Basically, there are two systems for the monitoring which are batch and continuous processes. Industrial batch processes scaled up to produce a larger quantity of material which requires precise tracking of batch information for safety and regulatory purposes. Continuous processes are done in precise ways at precise points. To ensure product quality and safety of operations precise control of process conditions must be maintained [4]. For this project, it will be using continuous monitoring system.

POME basically contains liquid waste that cannot easily or immediately being processed for extraction of useful products and will be run down to the mill internal drain system to the effluent (or sludge) pit [5]. Figure 2 show the process treatment of effluent water. Process of the digested liquid to be treated will be divided to 3 phases:

i. Acidic phase
ii. Methanogenic
iii. Aerobic phases

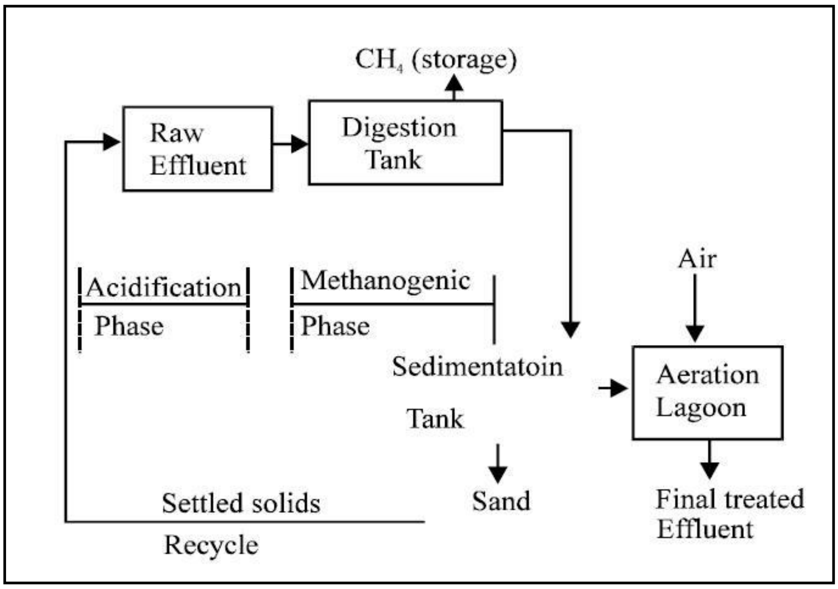

Figure 2 Flow Chart for Process Treatment of the Effluent Water [4].

For the palm oil mill management, the water must be regulated in terms of Biological oxygen demand (BOD), the chemical oxygen demand (COD), total solids (TS), suspended solids (SS), oil and grease (O & G), Ammonical nitrogen (NH3-N), pH, temperature and cost [5].

2.2.1 Parameters in the Process Treatment

Wastewater Treatment systems rely on microbes to operate the function of the breakdown of sewage influent. These microbes live in the sludge of treatment plants and holding tanks. In any wastewater treatment system there is a vast array of microbes present, i.e. aerobic, anaerobic and facultative, each performing specific functions in their respective parts of the system. Each species has a tolerance of ecological minimums and maximums with regard to various conditions; pH, temperature, dissolved oxygen levels and nutrient levels. All microbes require optimal conditions in order to proliferate and infuse the system with sufficient numbers of microbes to maximize the efficiency of the wastewater treatment plant [6].

BOD is a measure of the amount of "food" for bacteria found in river water. It is an aggregate measure of organic matter that includes all sorts of things. It depends on the fact that bacteria in the water will utilize organic matter in their respiration and thereby remove oxygen from the river [7]. BOD measurement procedure includes dilution, seeding and standard sample to check procedure. The Average temperature is = 20 degrees C. 300 ml are usually used. Dark Incuba0tion is needed to restrict the growth of algae. The final measurement is usually expressed as O2 mg/l. BOD measures all biodegradable organic carbons, and under certain conditions, oxidizable nitrogen present in the waste.

The methods for BOD determination are commonly used are the direct measurement of dissolved oxygen or DO-content of sample and different dilutions every day with a DO-probe and calculating the BOD at the end. The more convenient method for municipal waste water is a respirometric measurement and storing the data every 24 hours automatically the samples have not to be touched between filling the bottle and reading data after 5 days [8].

COD or Chemical Oxygen Demand is the total measurement of all chemicals in the water that can be oxidized. COD is usually measured and the test is simple and easy to perform with the right equipment and can be done in 2 hours while BOD usually takes 5 days. A COD test measures all organic carbon with the exception of certain aromatics (benzene, toluene, phenol, etc.) which are not completely oxidized in the reaction. COD is a chemically chelated/thermal oxidation reaction, and therefore, other reduced substances such as sulfides, sulfites, and ferrous iron will also be oxidized and reported as COD [9].

Wastewater usually contains large quantities of suspended solids that are organic and inorganic in nature. These solids are measured as Total Suspended Solids (TSS) and are expressed as mg TSS/ liter of water. This suspended material is objectionable primarily because it can be carried with the wastewater to the leach field. Because most suspended solids are small particles, they have the ability to clog the small pore spaces between soil grains in the leaching facility. There are several ways to reduce TSS in wastewater. The simplest method is the use of a septic tank effluent filter, such as the Zabel filter (several other brands are available). This type of filter fits on the outlet tee of the septic tank. It is made of PVC with various size slots fitted inside one another. The filter prevents passage of floating matter out of the septic tank and, as effluent filters through the slots, fine particles are also caught. Many types of alternative systems are also able to reduce TSS, usually by the use of settling compartments and/or filters using sand or other media [10].

A rough indication of pH can be obtained using pH papers or indicators, which change color as the pH level varies. More accurate pH measurements are obtained with a pH measurement system consisting of three parts: a pH measuring electrode, a reference electrode, and high input impedance meter [6]. The basic equation of the pH is as below

$$\mathrm{pH} = -\log_{10} a_{\mathrm{H}} = \log_{10} \frac{1}{a_{\mathrm{H}}}$$

where a_{H} is the (dimensionless) activity of hydrogen ions. These hydrogen ions respond to hydrogen ion activity that can be measured experimentally by means of an ion-selective electrode [11].

Temperature can be measured in many ways. The commonly used are thermistors and mercury thermometers. These are calibrated in the laboratory before being used, using mercury or platinum thermometers with accuracy traceable to national standards laboratories. Infrared radiometers on satellites measure the surface of water temperature [12]. Instead of these, there are inexpensive and versatile devices for measuring temperature which known as thermocouples. The measurements of these devices range from hand-held units to multichannel data acquisition systems. Thermocouples also can be used to measured wide range of temperature. This gives advantages to thermocouples instead of other devices [13].

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

In order to achieve the objectives of this project, research has been done on some resources such as books and technical papers. Due to this, flowchart of activities has been developed. Figure 3 shows the overall flowchart of the project in order to keep on scheduling the plan for the project.

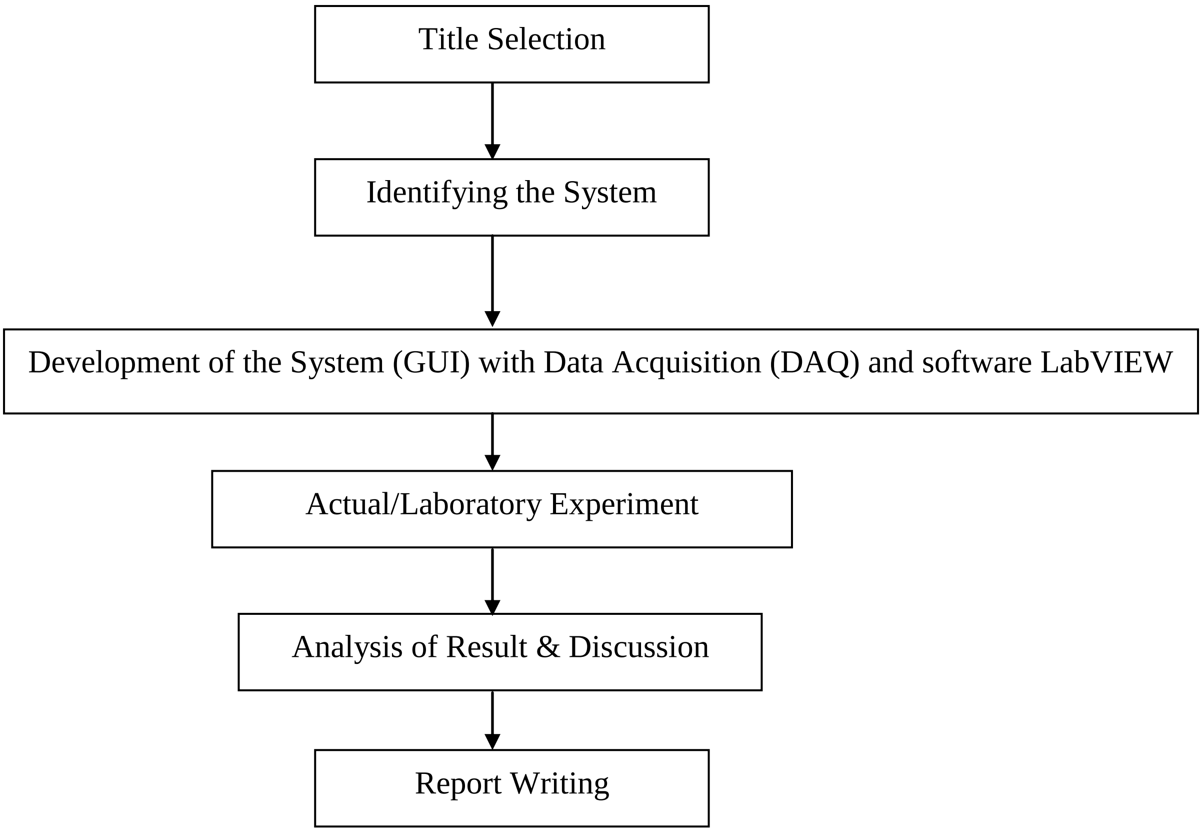

Figure 3 Project Activities Flow Chart

For the time being, the progress of the project right now is in the third and fourth stage which is development of the system interface and some experiments are still ongoing before proceed to the other stage. This is very important to know the system itself before it can be implemented through LabVIEW to generate data needed.

3.2 Methodology

The important thing of this project has been made throughout the methodology diagram below in Figure 4. This methodology includes the main 4 phase in development of the project that is really concerned throughout the course.

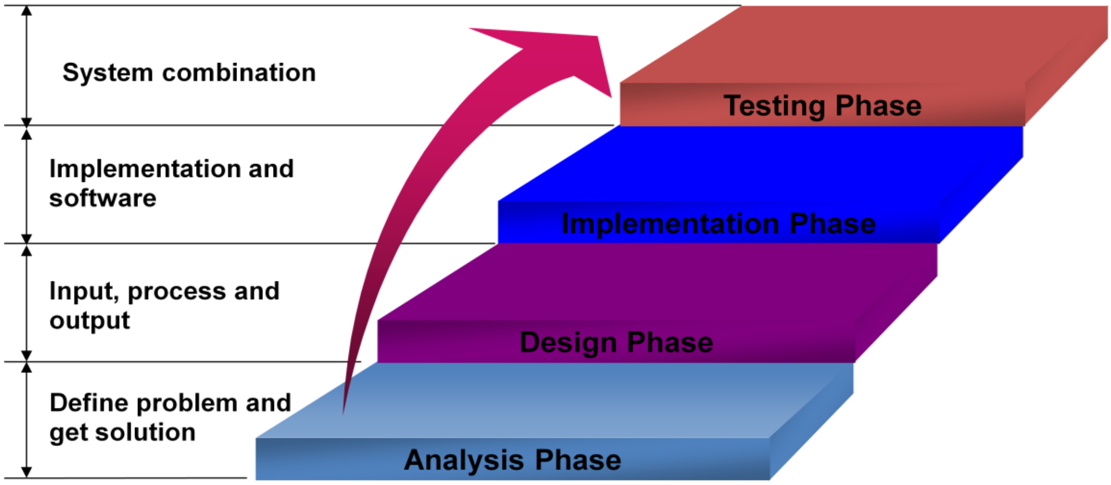

Figure 4 Methodology Diagram

The process for the prototype has gone through all the phase in order to keep in track with the requirement and objective of the overall project.

3.3 Requirements of the Project

3.3.1 Parameters Selection for the Project

After identifying all the parameters of the treatment process, 2 parameters have been selected to be implemented through the project of the online monitoring system. The 2 parameters that are selected:

1. pH
2. Temperature

The main focused throughout of the project will be on these 2 parameters. Work still ongoing to determine the best way to measure all the parameters through the probes to be implemented in the software and can be easily read by users.

3.3.2 Control Algorithm of Hardware

The concept of controlling the hardware is through a systematic approach. The algorithm involves the following steps:

i. Determine the sequence of operation in order to achieve objectives (parameters)
ii. Assignment of inputs and outputs to be determined [14].

3.3.3 Data Acquisition System Concept

Data acquisition refers to any process where information is converted into a form that can be handled by a computer. Computer based data acquisition system is a system where parameter, or parameters are detected by a sensor, the output signal is then suitably conditioned, and this data is then stored or processed by computer [15]. Figure 5 shows the path from sensor to computer.

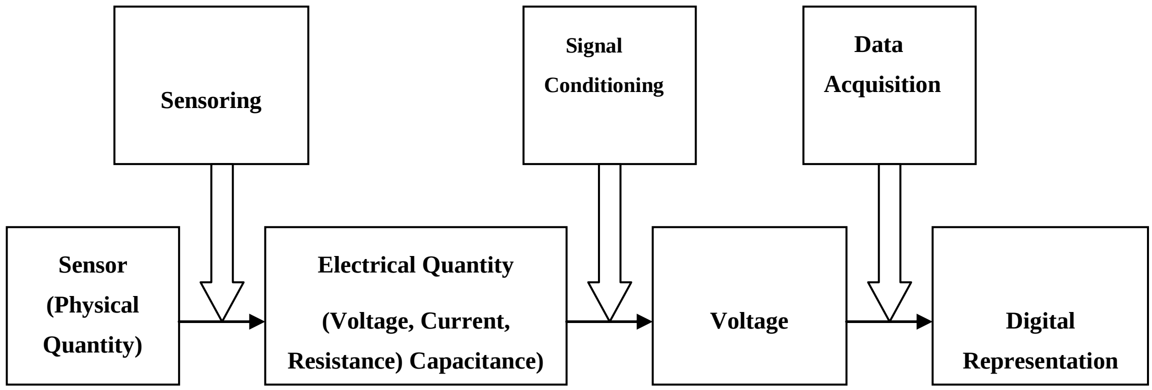

Figure 5 The Path from Sensor to Computer

There are some benefits for Data Acquisition System using DAQ which are:

i. Multifunction in industrial sector.
ii. Lower cost more than using traditional process.
iii. Faster perfomance.
iv. Data in real time and can storage
v. Better flexibility
vi. Easier system integration.

3.3.4 LabVIEW

LabVIEW is a graphical user interface (GUI) consists of two main panels, a control panel and a Display Panel. In the control panel, we have constructed VIs (Virtual Instruments) that will enable the user to have control over updating the period of the data acquisition as well as the data logging and storing information. On the Display Panel, we have placed charts that display the history of the parameters. This project requires of Guide User Interface (GUI) to help maximized the operation of the system while monitoring the recycling and treatment of the water from POME. Some testing in the laboratory really needed to test the availability of the software and the parameters.

3.3.5 Sensor Validation

The operation of each industrial plant is based on the readings of a set of sensors. Their reliable functioning is essential as the output of sensors provides the only objective information of the process. The task of the sensor validation is intended to confirm whether the sensors are functioning properly. The validation process must be robust enough to detect multiple sensor faults as well such as bias, drift, spike, short circuit, open circuit and cyclic noise. So the real-time process sensor validation is very important, based on the object-oriented flexible design and flexible control theory [16].

3.4 Tools Required

Some of the tools that may require during this project include:

- Software LabVIEW to generate GUI
- Data Acquisition (DAQ) card
- Sensors (for pH and temperature)
- Sample to be tested during development of the system

3.5 Cost Estimation

Cost that is considered in this project includes direct and indirect cost. Table 2 shows the estimation cost for this project.

Table 2 : Cost Estimation of the Project

Direct cost

Items	Quantity	Cost	Total Cost
Thermocouple	2	$12.00	$24.00
Tank	2	$50.00	$100.00
Stand	1	$100.00	$100.00
		Total	$224.00

Indirect cost

Items	Quantity	Cost	Total Cost
pH Meter	1	$300.00	$300.00
Software LabVIEW	1	$1,700.00	$1,700.00
DAQ Card	1	$300.00	$300.00
Computer	1	$2,500.00	$2,500.00
		Total	$4,800.00

Overall cost estimation = Direct cost + Indirect cost

= RM 224.00 + RM4800.00

= RM 5024.00

3.6 Project Development

The understanding of the system really needed before starting to the phase of development. The main part of the project is the development of the Guide User Interface (GUI) to ease the operator to monitor the system. Figure 6 shows the background development of the GUI itself.

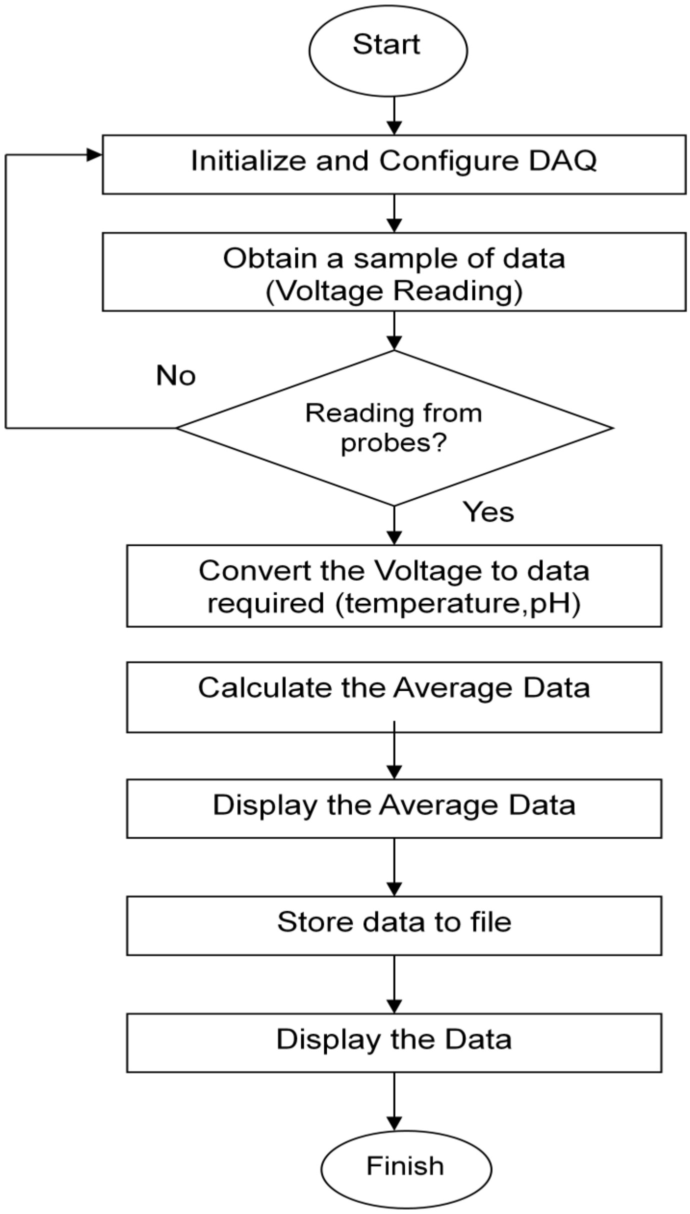

Figure 6 The main tasks being performed for GUI

3.7 Overall System Structure

Combining all the information and understanding of the project, the structure of the system has been developed. Figure 7 shows the overall system structure that has been divided to 3 main parts which were

1. Circuit sensors
2. Software including equipments
3. Visualization

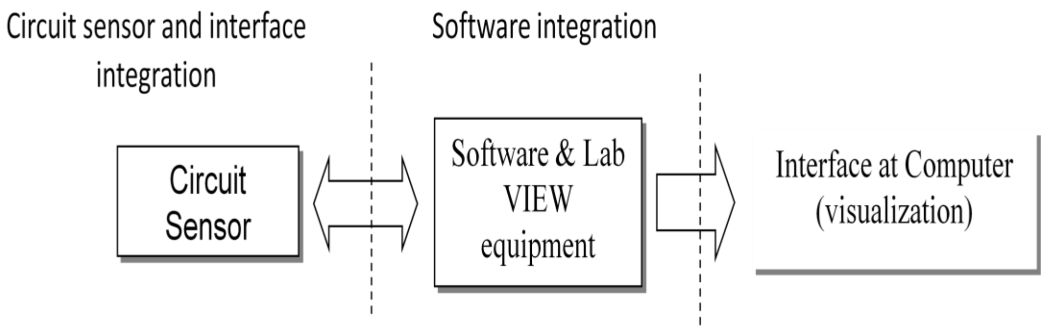

Figure 7 System Development Structure

The establishment of GUI then will be connected through DAQ card to get the real time data. These data then need to be analysed and compared with the data that has been stored in the system. The data being showed on the screen are the data that has been compared to the stored data to ease operator analyzed the quality of the water. Figure 8 shows the project visualization after all the setting has been established.

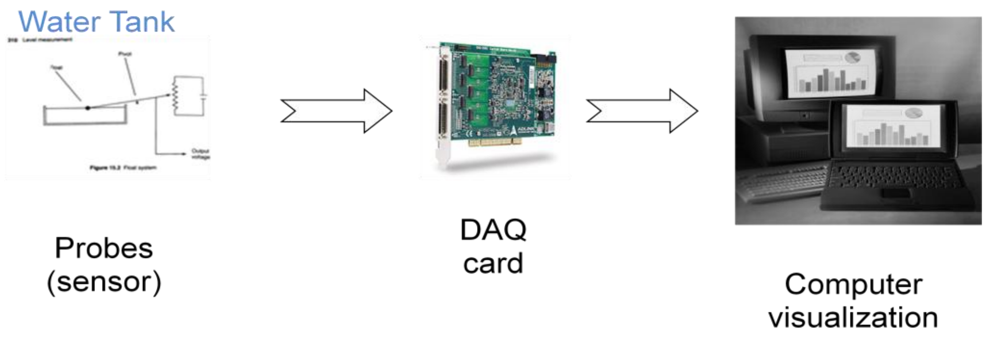

Figure 8 Project Visualization

CHAPTER 4
RESULT AND DISCUSSION

This project so far has been divided into two parts already. First part is the prototype of the project which is fabrication of the tank. Second part is the development of the interface for the monitoring system. At the end the system will be combined together. Figure 9 below is the illustration of the final prototype of the project. Refer appendix for the mechanical system of this project.

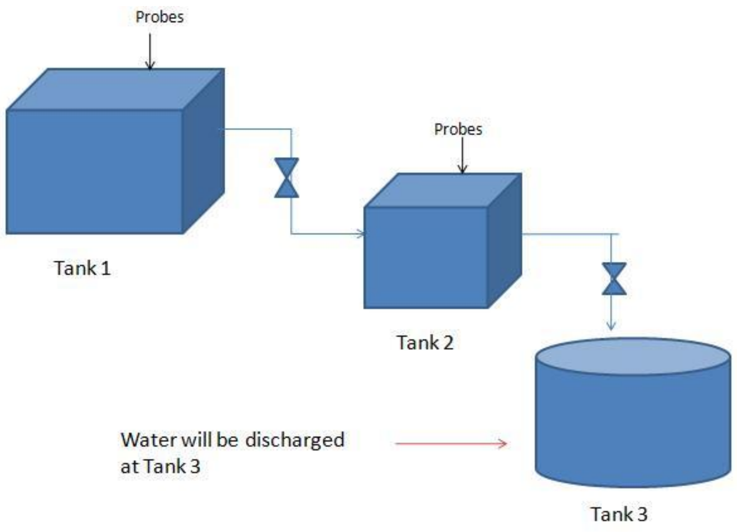

Figure 9 Illustration of the Project Prototype

4.1 Fabrication of the Tank

In the industry, POME was treated in the tank. With a hydraulic retention time of 20 days, each digesting tank has the capacity of 3600 m^3 of POME. For the open digesting tank, the dimension is 19.5 m×12.2 m (diameter × height) to treat 180 m^3 day^{-1} of raw POME. This treated POME is then displaced into the facultative anaerobic ponds using gravity flow [17].

For this project, the prototype will be scaled down to a suitable design. Two tank which represent the mill (tank 1) and the tank to treat the POME itself (tank 2). Tank 1 has dimension of about 40cm×30cm×30 cm while tank 2 with 30cm×30cm×30cm. Figure 10 below show the tank that has been fabricated for the prototype.

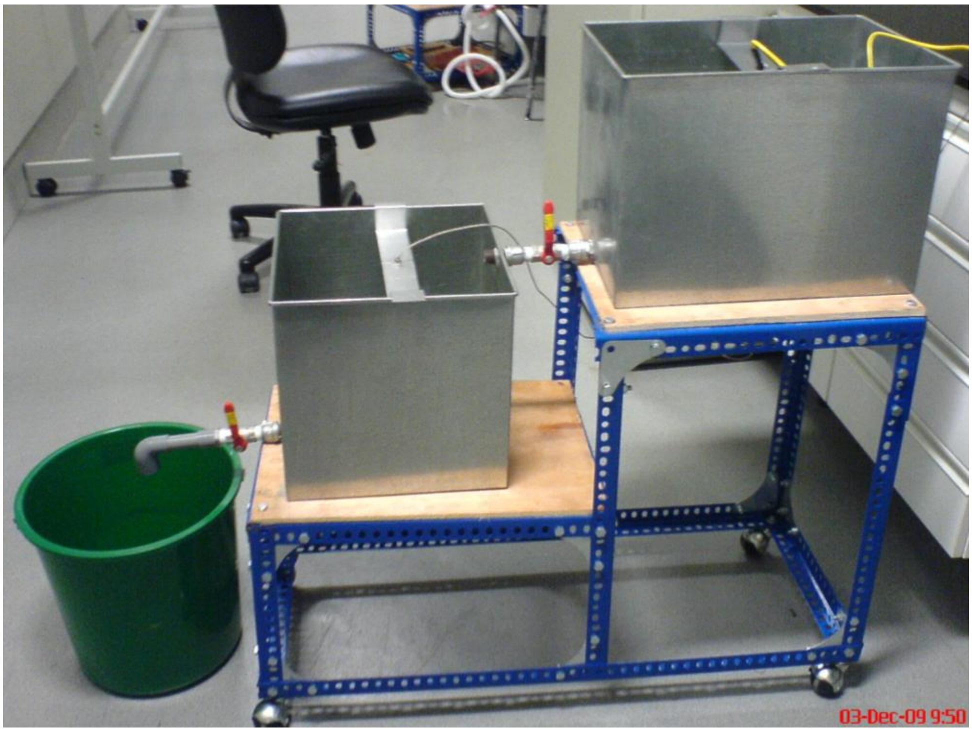

Figure 10 Fabrication of the Tank

4.2 Development of Interface using LabVIEW

The development of interface using LabVIEW is still ongoing. Some progress has been done through this semester.

4.2.1 Interface Development

Using LabVIEW 6i from National Instrument, the interface for the system so far is doing goods. Some explanations really needed to verify the system itself. Figure 11 shows the loop diagram used in the system. The function of the while loop diagram is to make sure the system is in continuous condition (looping).

Figure 11 While Loop Diagram

This while loop diagram working so fast to get the data. In order to slow down the process, there is need for Wait until Next ms Multiple as shown in Figure 12.

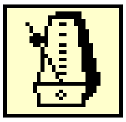

Figure 12 Wait until Next ms Multiple diagram

These two diagrams will be combined together with the system in order to get the data in suitable time manner in continuous way. The other diagrams then will be applied in this while loop to get the desire data. Figure 13 and 14 show the interface of LabVIEW that has been done for thermocouple while Figure 15 shows the block diagram of the interface itself. This block diagram is setup to get the required data.

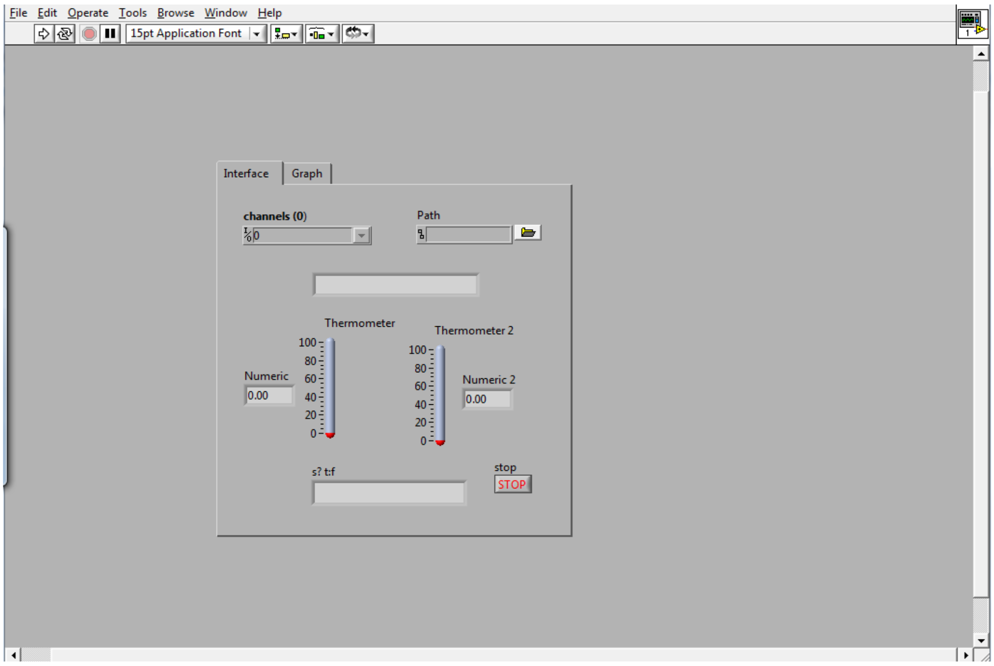

Figure 13 Interface of Thermocouple

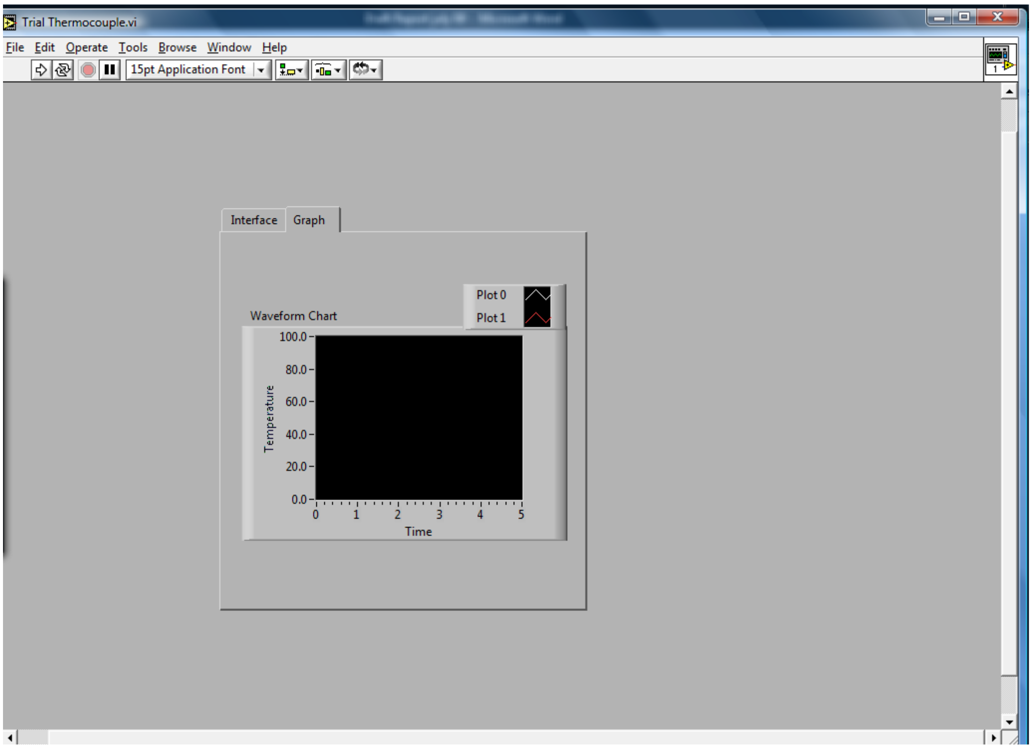

Figure 14 Interface for the Graph

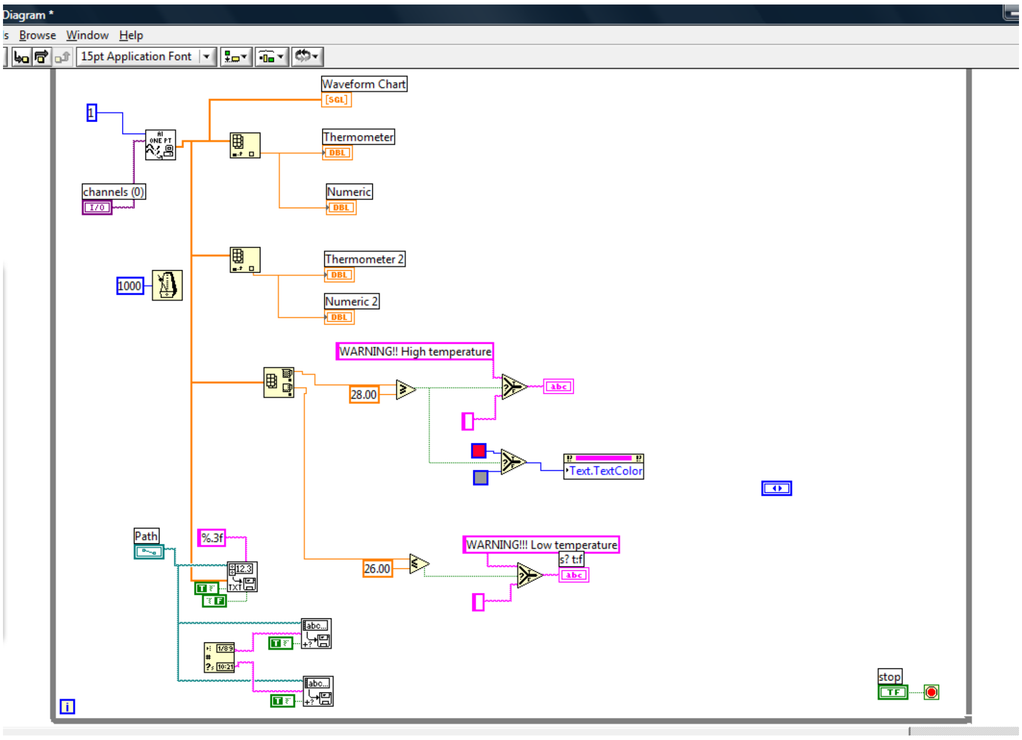

Figure 15 Block Diagram for Thermocouple's Interface

4.2.2 *Callibration of thermocouple*

So far, calibration of the thermocouple has been done. At the same time, the interface for thermocouple which sense temperature is doing goods. Thermocouple can now sense the temperature of the surroundings.

Before using the interface, user first has to assign which channel has to be assigned according to the system interface using Measurement and Automation Explorer (MAX). Figure 16 and 17 show the pin assignment for the sensor in MAX.

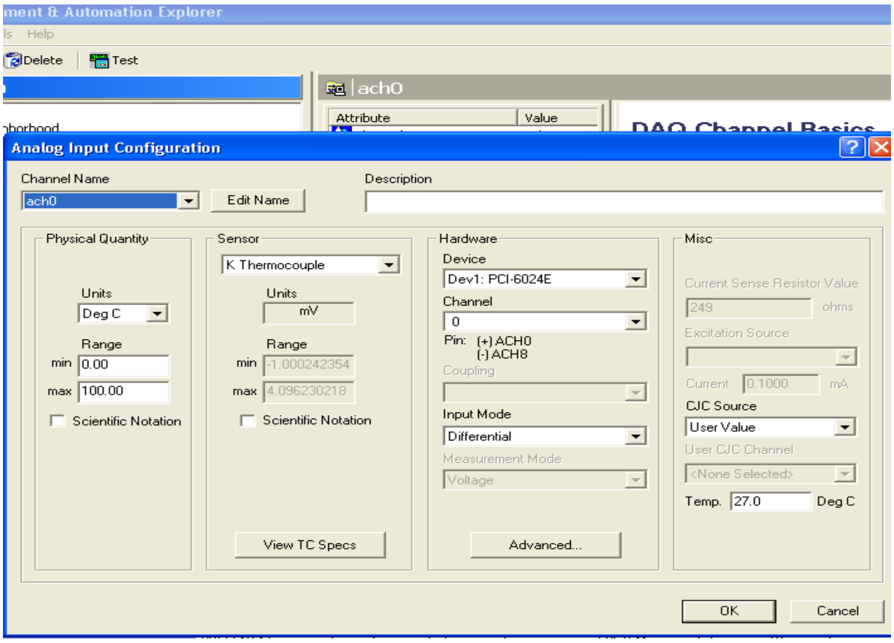

Figure 16 Assign Input Channel for ach0 in MAX

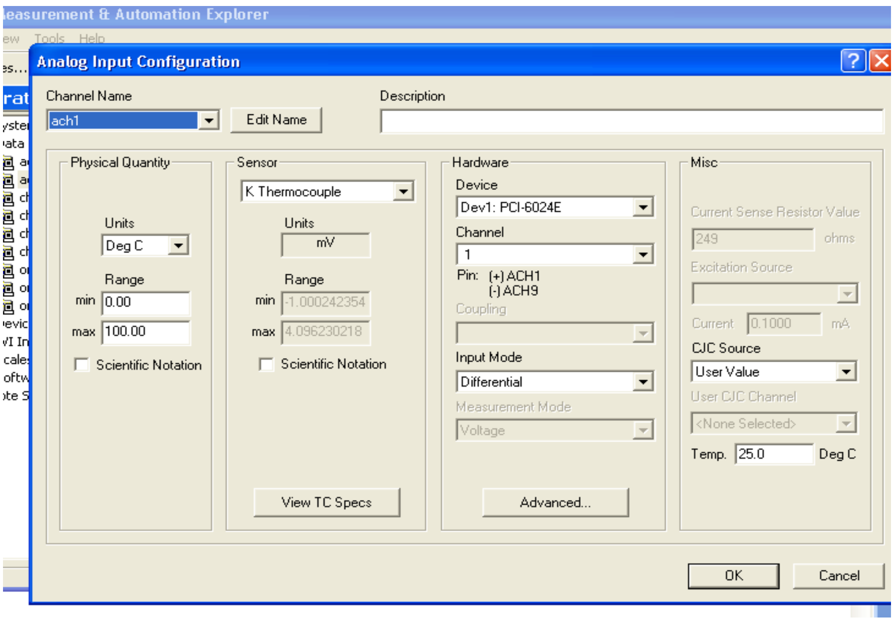

Figure 17 Assign Input Channel for ach1 in MAX

Then, the connection will be done for the pin at pin block. This pin assignment must be the same as indicated in MAX in order to get the data correctly. Figure 18 shows the pin assignment at the connector block. the pin assignment must follow the wiring diagram (Refer Appendix C).

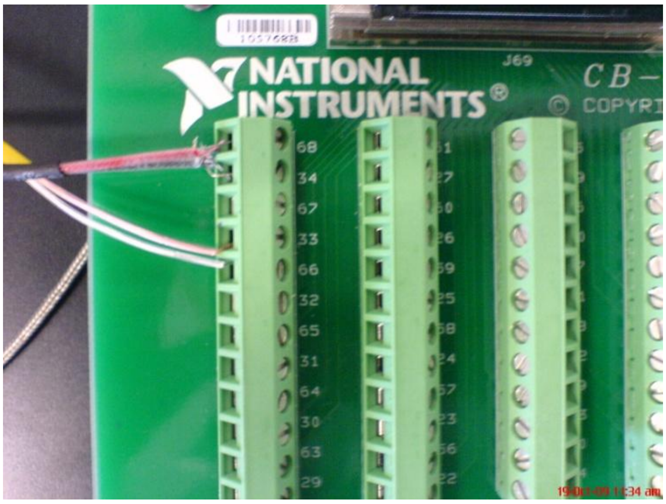

Figure 18 Pin Assignment at the Connector Block

At the interface in LabVIEW, there is also some point where user needs to assign the channel for the system and also where all the data should be kept. After the setup being done, user can now run the program and the result will appear at interface as shown in Figure 19.

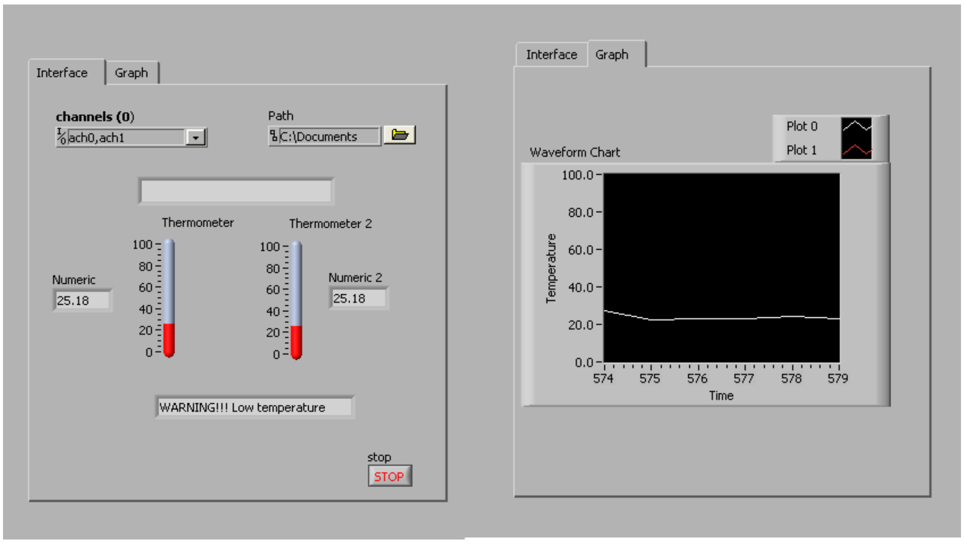

Figure 19 Result from Thermocouple

The system will alert the user if there is problem for the monitoring system as shown in Figure 20

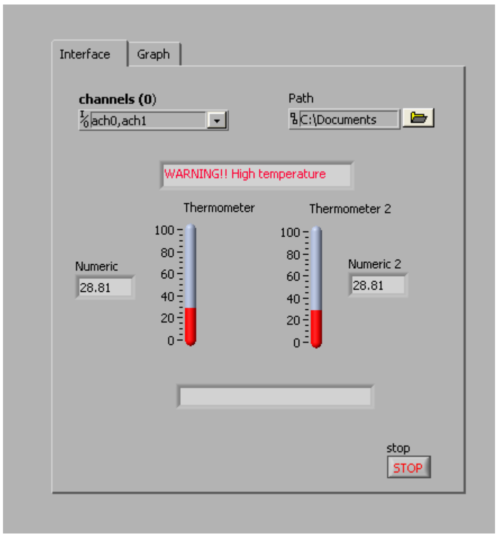

Figure 20 Alert to User in the Interface

4.2.3 pH Calibration

The development of the pH measurement is through the basic measurement. Figure 21 shows the interface for pH measurement.

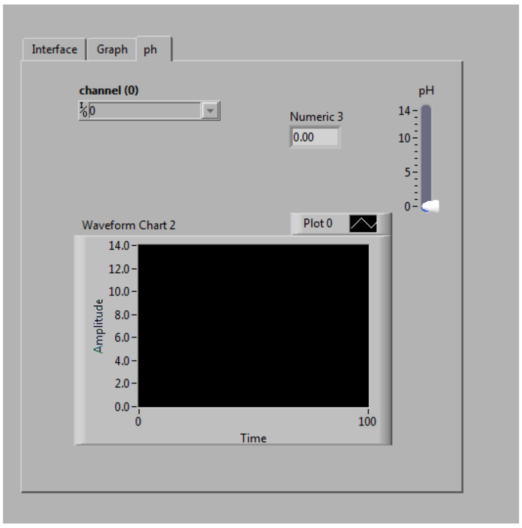

Figure 21 Interface for pH Measurement

Figure 22 below shows the VI diagram for the pH interface of the project.

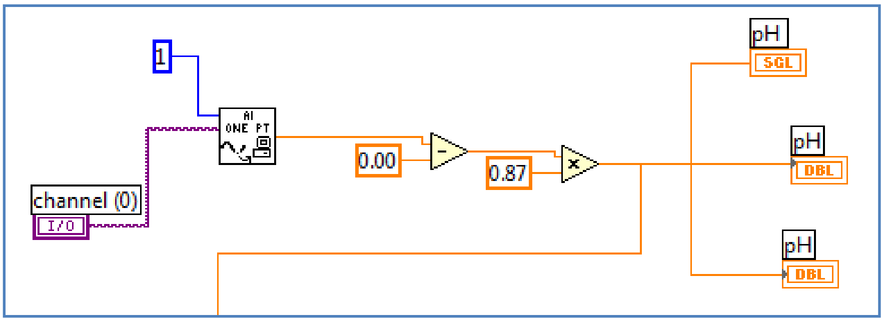

Figure 22 VI Diagram for pH Measurement

4.2.4 System Combination of the Interface

At the end of implementation of the project, the system for temperature and pH measurement will be combined together as for the requirement of the project. Figure 23 below shows the overall interface of the project.

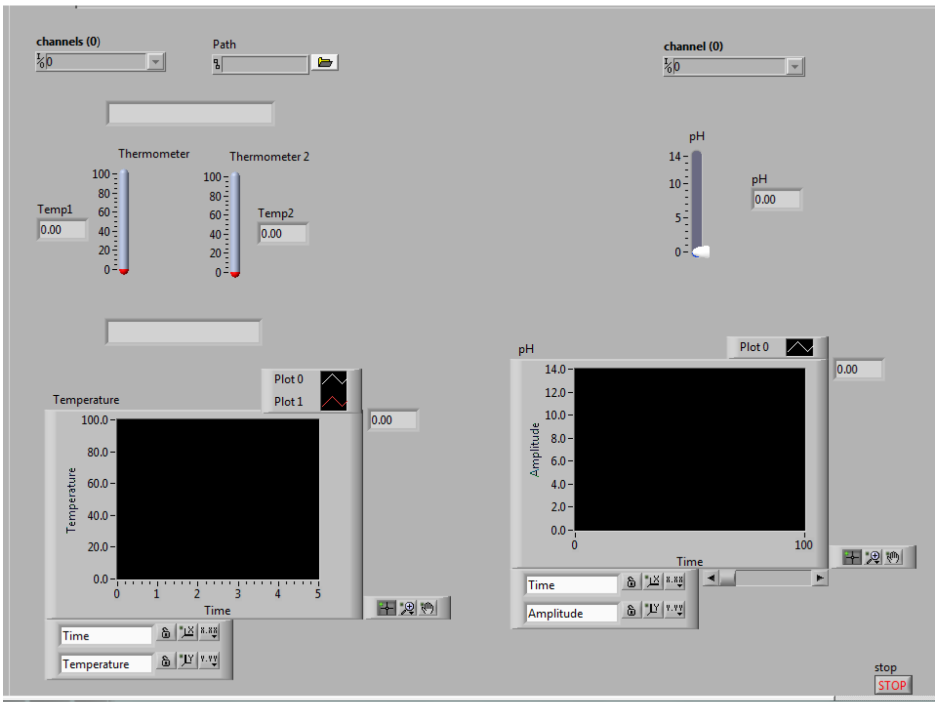

Figure 23 Project Interface

Figure 24 below shows the overall VI diagram of the system to build the interface in LabVIEW software.

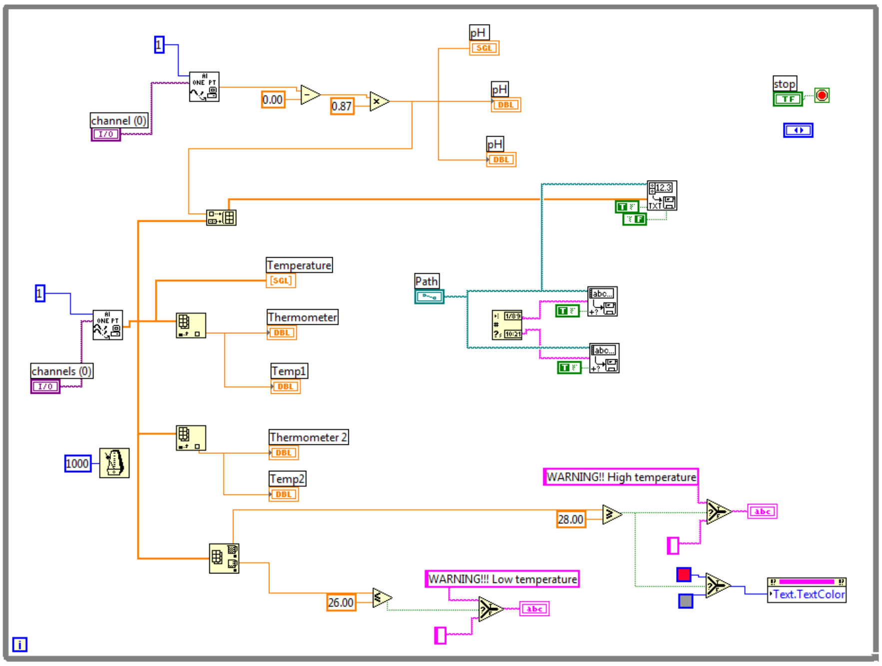

Figure 24 VI Diagram for the Overall Interface

4.3 Results

After several tests and experiments conducting throughout the project, the interface and the system seems to work very well. The readings can be obtained through the interface and all the data can be saved to be monitored and compared later by the operator. Figure 25 shows the reading of the interface that working (refer Appendix A for the data storage).

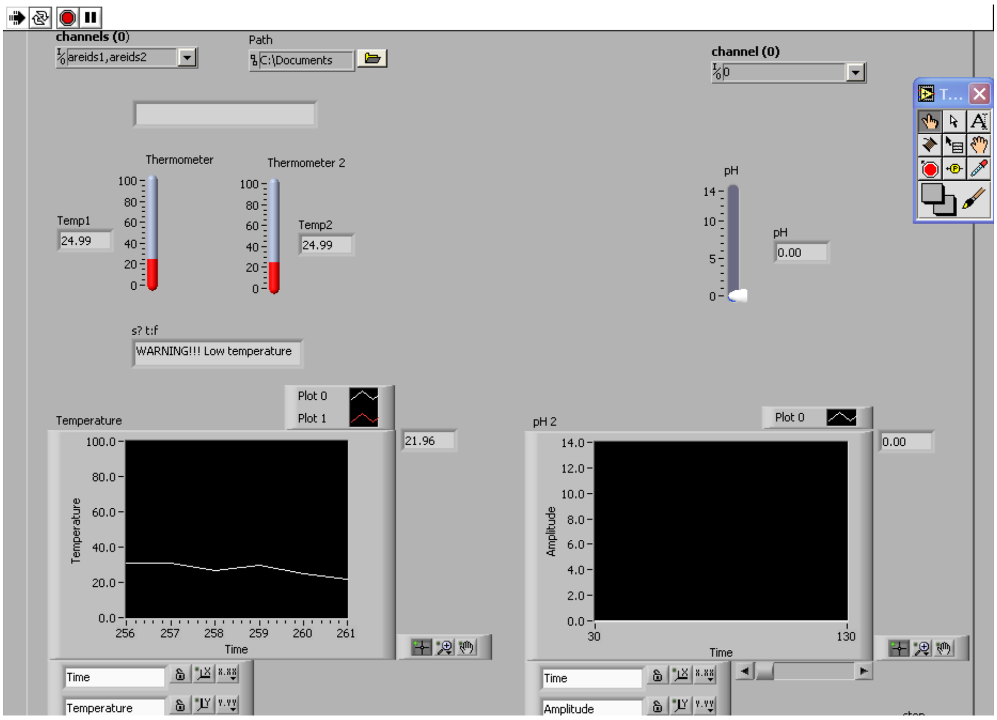

Figure 25 Results of the Project

CHAPTER 5
CONCLUSION & RECOMMENDATION

5.1 Conclusion

Laboratory experiment that has been conducted to analyze the control system in the palm oil mill and optimize the use of the system shows good progress. The experiments and tests can be said as success to achieve the objective. The development of the Guide User Interface (GUI) via LabVIEW and interfacing the data from Data Acquisition (DAQ) card will ease the online monitoring system for the process of water recycling from palm oil mill effluents.

5.2 Recommendation

The system is still new in implementation. Some improvements can be done in the future to upgrade the system. The system could be improved further by:

1. Including BOD/COD sensors for a better results
2. The system could have online capability so that the data that is being processed could be observed quickly (server and client model via networking).

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APPENDICES

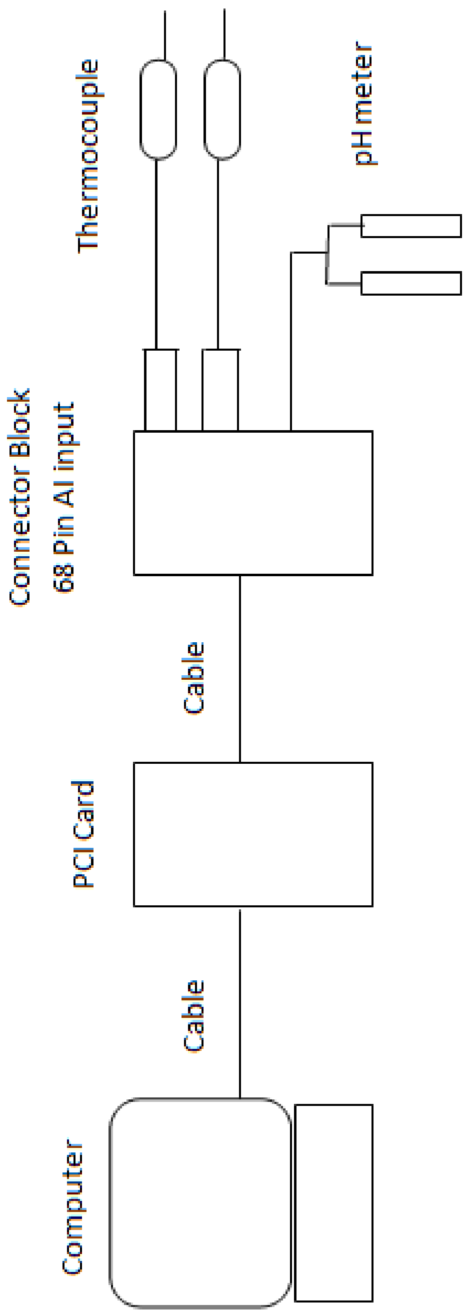
APPENDIX A

PROJECT RESULT

10:00	AM12/3/2009	-0.008	22.568	21.962
10:00	AM12/3/2009	-0.008	24.385	29.816
10:00	AM12/3/2009	-0.004	15.274	11.002
10:01	AM12/3/2009	-0.008	17.102	12.834
10:01	AM12/3/2009	0.001	24.385	17.102
10:01	AM12/3/2009	-0.012	24.990	11.613
10:02	AM12/3/2009	0.001	25.594	20.142
10:02	AM12/3/2009	-0.004	26.802	19.534
10:02	AM12/3/2009	0.001	40.000	33.421
10:03	AM12/3/2009	-0.004	14.665	20.749
10:03	AM12/3/2009	0.001	28.009	12.834
10:03	AM12/3/2009	0.001	22.568	21.962
10:04	AM12/3/2009	-0.008	5.494	21.356
10:04	AM12/3/2009	0.005	23.174	12.834
10:04	AM12/3/2009	0.001	32.221	33.421
10:05	AM12/3/2009	0.001	23.174	20.142
10:05	AM12/3/2009	-0.012	24.990	33.421
10:05	AM12/3/2009	0.001	12.834	7.331
10:06	AM12/3/2009	0.001	25.594	-0.634
10:06	AM12/3/2009	0.009	21.962	21.356
10:06	AM12/3/2009	-0.004	24.990	21.356
10:06	AM12/3/2009	-0.004	17.710	23.174
10:07	AM12/3/2009	0.001	22.568	17.102
10:07	AM12/3/2009	-0.004	24.385	21.356
10:07	AM12/3/2009	-0.004	23.174	23.174
10:08	AM12/3/2009	0.001	24.990	19.534
10:08	AM12/3/2009	-0.004	26.198	19.534
10:08	AM12/3/2009	-0.004	13.445	12.223
10:09	AM12/3/2009	-0.008	22.568	12.834
10:09	AM12/3/2009	-0.004	27.406	25.594
10:09	AM12/3/2009	-0.004	24.990	22.568
10:10	AM12/3/2009	0.005	23.780	22.568
10:10	AM12/3/2009	-0.004	24.990	20.142
10:10	AM12/3/2009	0.001	21.962	14.665
10:11	AM12/3/2009	-0.004	22.568	17.710
10:11	AM12/3/2009	-0.004	26.198	19.534
10:11	AM12/3/2009	0.001	27.406	20.749
10:12	AM12/3/2009	0.001	28.611	52.460
10:12	AM12/3/2009	-0.008	34.620	9.167
10:12	AM12/3/2009	0.001	24.990	22.568
10:13	AM12/3/2009	-0.008	23.780	24.385
10:13	AM12/3/2009	-0.004	24.385	19.534
10:14	AM12/3/2009	-0.008	20.749	27.406
10:14	AM12/3/2009	0.001	53.050	21.356
10:14	AM12/3/2009	-0.004	0.594	23.780
10:15	AM12/3/2009	-0.004	24.990	30.418
10:15	AM12/3/2009	0.001	14.665	-3.107
10:15	AM12/3/2009	0.005	17.102	21.356
10:16	AM12/3/2009	-0.004	7.331	22.568

APPENDIX B

WIRING DIAGRAM



APPENDIX C

PCI 6024E DATASHEET

Low-Cost E Series Multifunction DAQ – 12 or 16-Bit, 200 kS/s, 16 Analog Inputs

NI E Series – Low-Cost

- 16 analog inputs at up to 200 kS/s, 12 or 16-bit resolution
- Up to 2 analog outputs at 10 kS/s, 12 or 16-bit resolution
- 8 digital I/O lines (TTL/CMOS); two 24-bit counter/timers
- Digital triggering
- 4 analog input signal ranges
- NI-DAQ driver that simplifies configuration and measurements

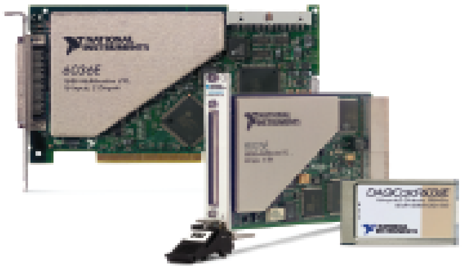
Families
- NI 6036E
- NI 6034E
- NI 6025E
- NI 6024E
- NI 6023E

Operating Systems
- Windows 2000/NT/XP
- Real-time performance with LabVIEW
- Others such as Linux® and Mac OS X

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Other Compatible Software
- Visual Basic, C/C++, and C#

Driver Software (included)
- NI-DAQ 7



Family	Bus	Analog Inputs	Input Resolution	Max Sampling Rate	Input Range	Analog Outputs	Output Resolution	Output Rate	Output Range	Digital I/O	Counter/Timers	Triggers
NI 6036E	PCI, PCMCIA	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	2	16 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6034E	PCI	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	0	–	–	–	8	2, 24-bit	Digital
NI 6025E	PCI, PXI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6024E	PCI, PCMCIA	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6023E	PCI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	0	–	–	–	8	2, 24-bit	Digital

[1] 10 kS/s typical when using the single DMA channel for analog output. 1 kS/s maximum when using the single DMA channel for either analog input or counter/timer operations. 1 kS/s maximum for PCMCIA DAQCard devices in all cases

Table 1. Low-Cost E Series Model Guide

Overview and Applications

National Instruments low-cost E Series multifunction data acquisition devices provide full functionality at a price to meet the needs of the budget-conscious user. They are ideal for applications ranging from continuous high-speed data logging to control applications to high-voltage signal or sensor measurements when used with NI signal conditioning. Synchronize the operations of multiple devices using the RTSI bus or PXI trigger bus to easily integrate other hardware such as motion control and machine vision to create an entire measurement and control system.

Highly Accurate Hardware Design

NI low-cost E Series DAQ devices include the following features and technologies:

Temperature Drift Protection Circuitry – Designed with components that minimize the effect of temperature changes on measurements to less than 0.0010% of reading/°C.

Resolution-Improvement Technologies – Carefully designed noise floor maximizes the resolution.

Onboard Self-Calibration – Precise voltage reference included for calibration and measurement accuracy. Self-calibration is completely software controlled, with no potentiometers to adjust.

NI DAQ-STC – Timing and control ASIC designed to provide more flexibility, lower power consumption, and a higher immunity to noise and jitter than off-the-shelf counter/timer chips.

NI MITE – ASIC designed to optimize data transfer for multiple simultaneous operations using bus mastering with one DMA channel, interrupts, or programmed I/O.

NI PGIA – Measurement and instrument class amplifier that guarantees settling times at all gains. Typical commercial off-the-shelf amplifier components do not meet the settling time requirements for high-gain measurement applications.

PFI Lines – Eight programmable function input (PFI) lines that you can use for software-controlled routing of interboard and intraboard digital and timing signals.

RTSI or PXI Trigger Bus – Bus used to share timing and control signals between two or more PCI or PXI devices to synchronize operations.

RSE Mode – In addition to differential and nonreferenced single-ended modes, NI low-cost E Series devices offer the referenced single-ended (RSE) mode for use with floating-signal sources in applications with channel counts higher than eight.

Onboard Temperature Sensor – Included for monitoring the operating temperature of the device to ensure that it is operating within the specified range.

NATIONAL INSTRUMENTS

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	NI 6034E, NI 6035E	NI 6023E, NI 6024E, NI 6025E	PCI-6013, PCI-6014
Measurement Sensitivity[1] (mV)		0.0023	0.0025	0.009	0.008	0.0036	0.008	0.004
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.147	4.747	14.369	15.373	7.560	16.504	8.984
5	-5	2.077	0.876	5.193	5.697	1.790	5.263	2.003
2.5	-2.5	–	1.190	3.606	3.859	–	–	–
2	-2	0.836	–	–	–	–	–	–
1	-1	0.422	0.479	1.452	1.558	–	–	–
0.5	-0.5	0.215	0.243	0.735	0.786	0.269	0.846	0.471
0.25	-0.25	–	0.137	0.370	0.405	–	–	–
0.2	-0.2	0.102	–	–	–	–	–	–
0.1	-0.1	0.061	0.084	0.163	0.178	–	–	–
0.05	-0.05	–	0.035	0.094	0.108	0.0611	0.106	0.068
10	0	0.876	1.232	6.765	7.269	–	–	–
5	0	1.892	2.119	5.394	5.846	–	–	–
2	0	0.802	0.850	2.167	2.271	–	–	–
1	0	0.405	0.428	1.092	1.148	–	–	–
0.5	0	0.207	0.242	0.559	0.583	–	–	–
0.2	0	0.096	0.111	0.238	0.247	–	–	–
0.1	0	0.059	0.059	0.127	0.135	–	–	–

Note: Accuracies are valid for measurements following an internal calibration. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 pt averaging of data.
[1]Smallest detectable voltage change in the input signal at the smallest input range.

Table 2. E Series Analog Input Absolute Accuracy Specifications

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	NI 6034E, NI 6035E	NI 6023E, NI 6024E, NI 6025E	PCI-6013, PCI-6014
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.450	1.405	8.127	8.127	2.417	8.127	3.835
10	0	1.201	1.176	5.686	5.685	–	–	–

Table 3. E Series Analog Output Absolute Accuracy Specifications

High-Performance, Easy-to-Use Driver Software

NI-DAQ is the robust driver software that makes it easy to access the functionality of your data acquisition hardware, whether you are a beginning or advanced user. Helpful features include:

Automatic Code Generation – DAQ Assistant is an interactive guide that steps you through configuring, testing, and programming measurement tasks and generates the necessary code automatically for NI LabVIEW, LabWindows/CVI, or Measurement Studio.

Cleaner Code Development – Basic and advanced software functions have been combined into one easy-to-use yet powerful set to help you build cleaner code and move from basic to advanced applications without replacing functions.

High-Performance Driver Engine – Software-timed single-point input (typically used in control loops) with NI-DAQ achieves rates of up to 50 kHz. NI-DAQ also delivers maximum I/O system throughput with a multithreaded driver.

Test Panels – With NI-DAQ, you can test all of your device functionality before you begin development.

Scaled Channels – Easily scale your voltage data into the proper engineering units using the NI-DAQ Measurement Ready virtual channels by choosing from a list of common sensors and signals or creating your own custom scale.

LabVIEW Integration – All NI-DAQ functions create the waveform data type, which carries acquired data and timing information directly into more than 400 LabVIEW built-in analysis routines for display of results in engineering units on a graph.

For information on applicable hardware for NI-DAQ 7, visit ni.com/dataacquisition.

Visit ni.com/oem for quantity discount information.

Recommended Accessories

Signal conditioning is required for sensor measurements or voltage inputs greater than 10 V. National Instruments SCXI is a versatile, high-performance signal conditioning platform, intended for high-channel-count applications. NI SCC products provide portable, flexible signal conditioning options on a per-channel basis. Both signal conditioning platforms are designed to increase the performance and reliability of your DAQ system, and are up to 10 times more accurate than terminal blocks (please visit **ni.com/sigcon** for more details). Refer to the table below for more information:

Sensor Signals (>10 V)

System Description	DAQ Device	Signal Conditioning
High-performance	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCXI
Low-cost, portable	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCC

Signals (<10 V)[1]

System Description	DAQ Device	Terminal Block	Cable
Shielded	PCI-60xxE	SCB-68	SH6868-EP
Shielded	PXI-60xxE	TB-2705	SH6868-EP
Shielded	DAQCard-60xxE	SCB-68	SHC6868-EP
Low-cost	PCI-6025E/PXI-6025E	Two TBX-68s	SH1006868
Low-cost	PCI-60xxE/PXI-60xxE	CB-68LP	R6868
Low-cost	DAQCard-60xxE	CB-68LP	RC6868

[1]Terminal blocks do not provide signal conditioning (i.e., filtering, amplification, isolation, and so on), which may be necessary to increase the accuracy of your measurements.

Table 4. Recommended Accessories

Ordering Information

PCI

NI PCI-6036E 778465-01
NI PCI-6034E 778075-01
NI PCI-6025E 777744-01
NI PCI-6024E 777743-01
NI PCI-6023E 777742-01

PCMCIA

NI DAQCard-6036E 778561-01
NI DAQCard-6024E 778269-01

PXI

NI PXI-6025E 777799-01

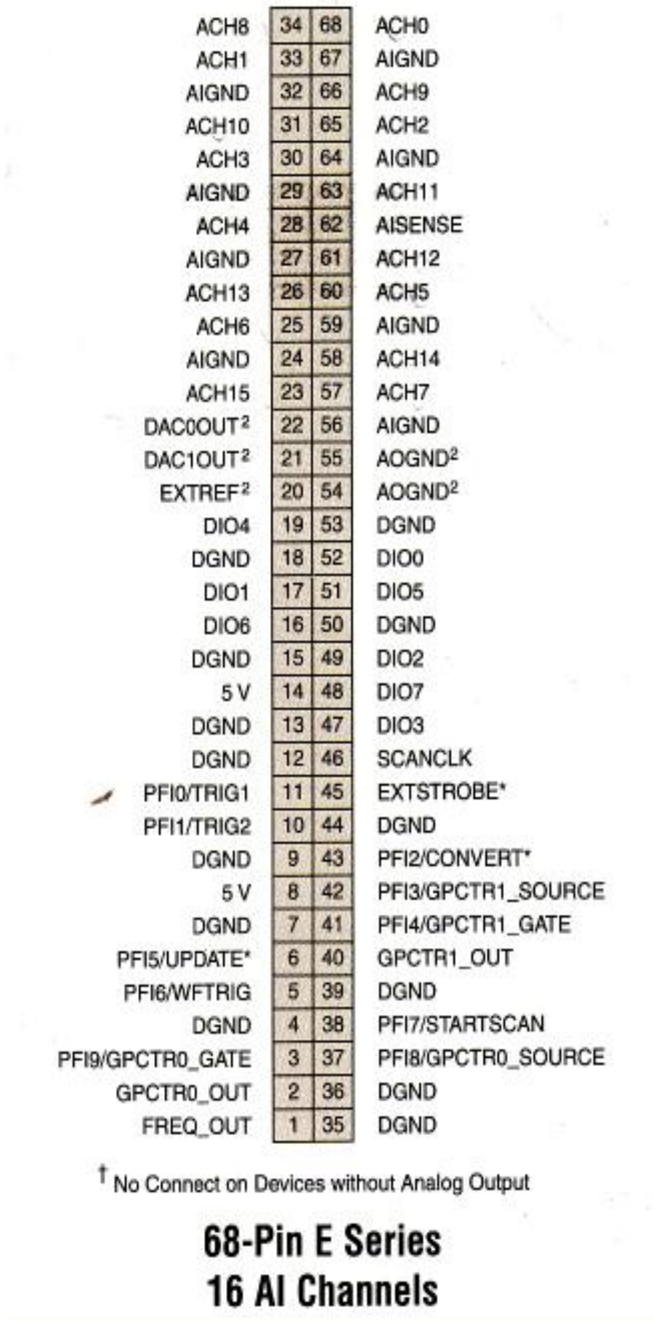
Includes NI-DAQ driver software.

BUY NOW!

For complete product specifications, pricing, and accessory information, call (800) 813 3693 (U.S.) or go to ni.com/dataacquisition.

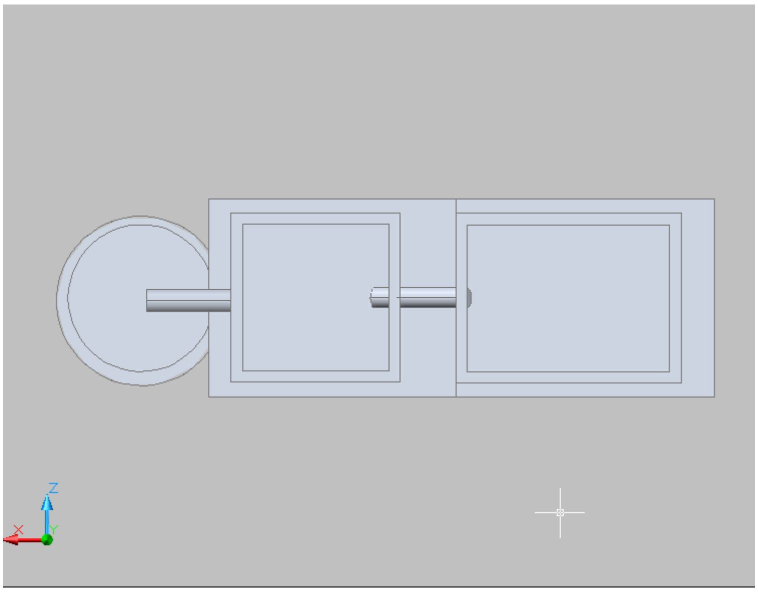
APPENDIX D

WIRING DIAGRAM CONNECTOR BLOCK

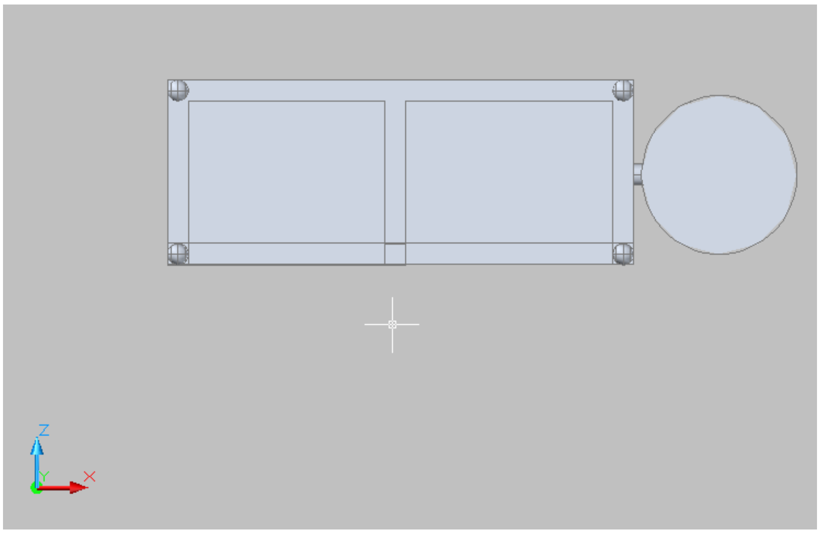


APPENDIX E

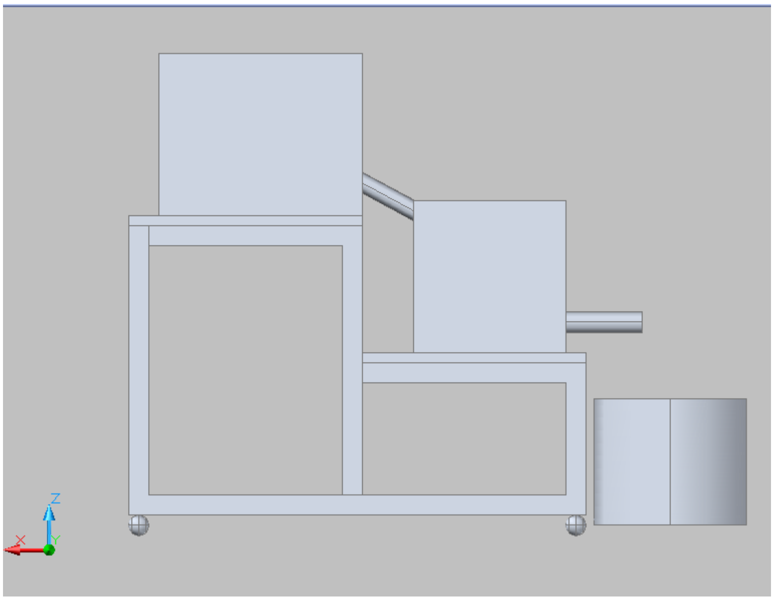
DETAIL DRAWING



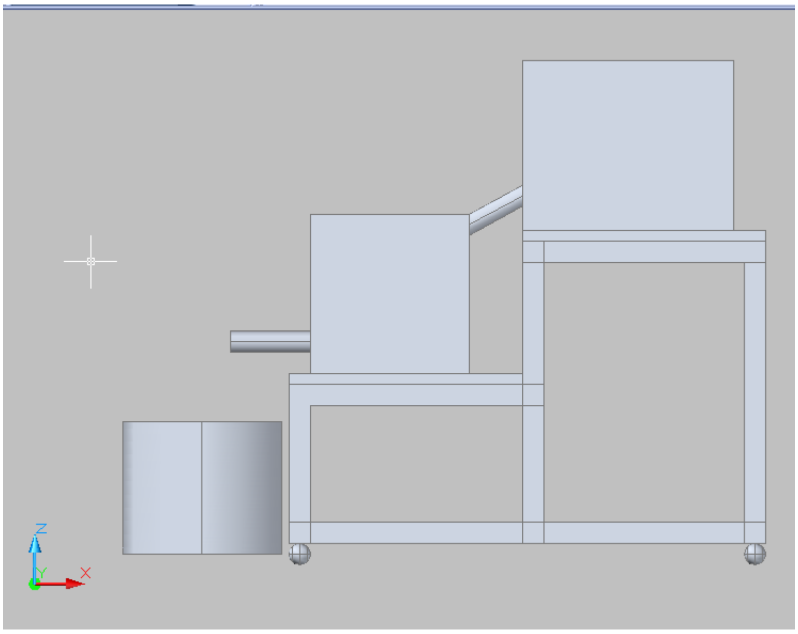
Top View



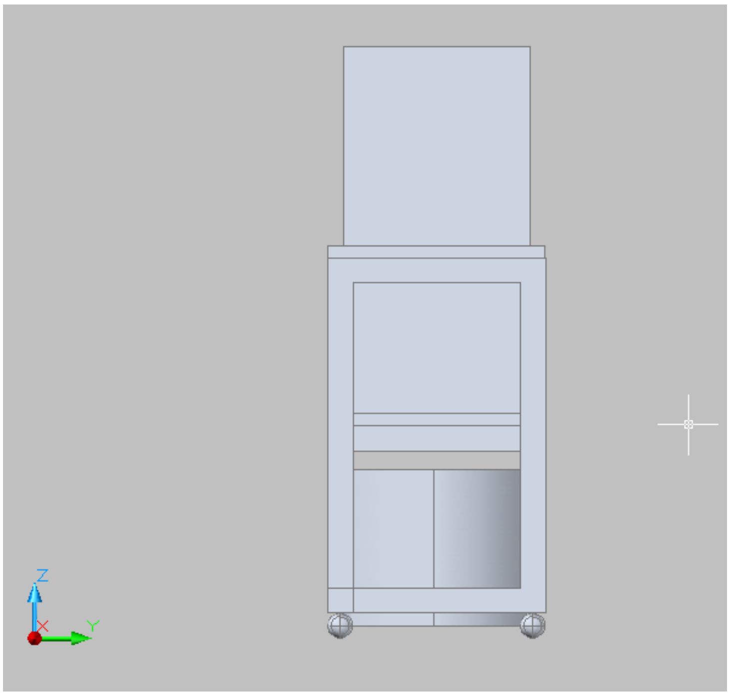
Bottom View



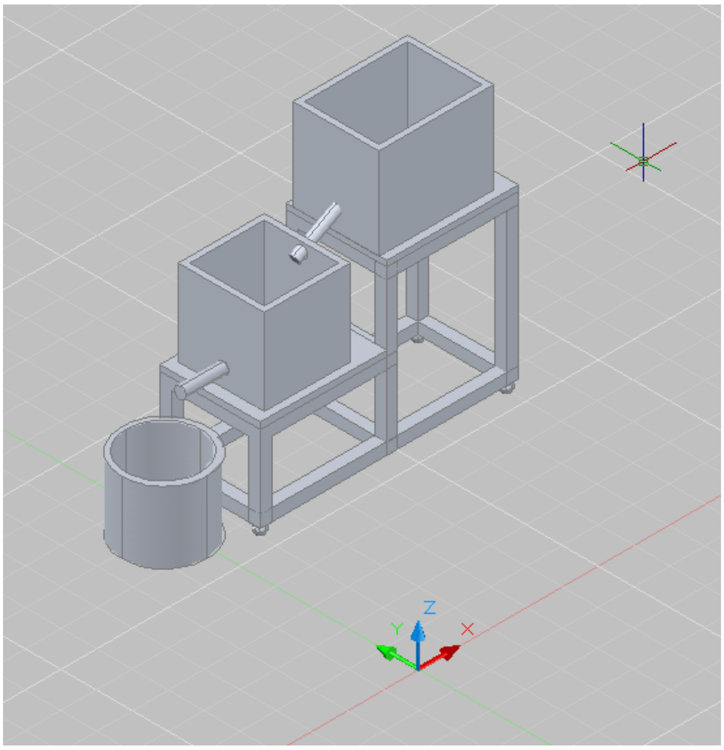
Side View (Left)



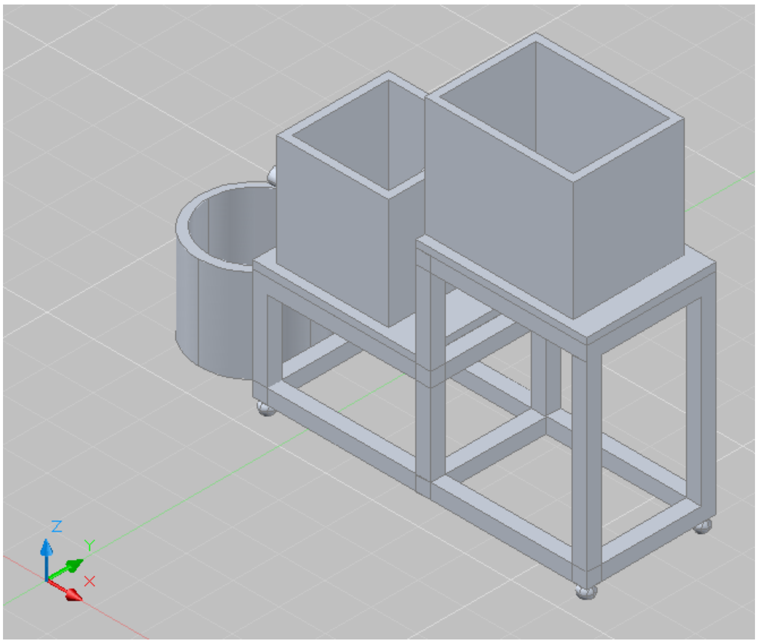
Side View (Right)



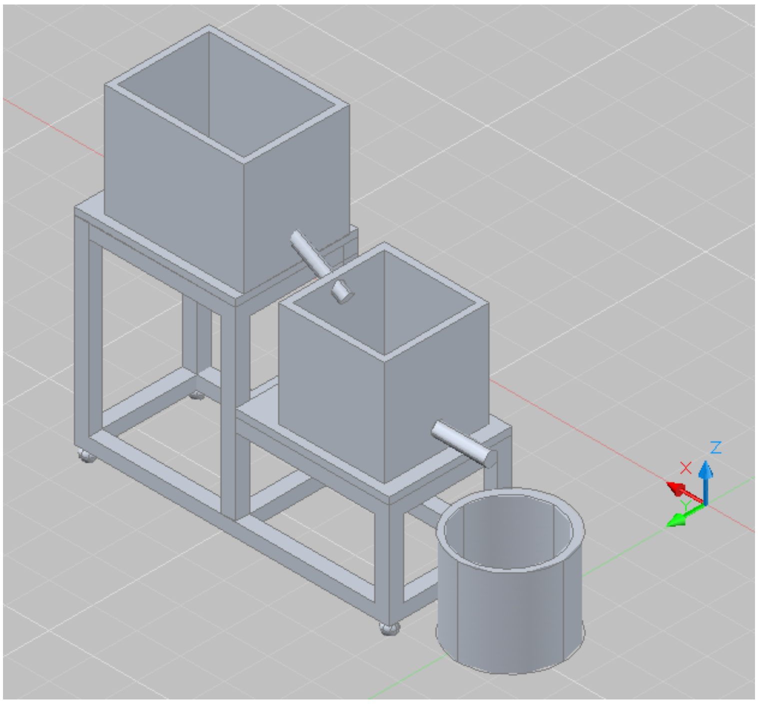
Back View



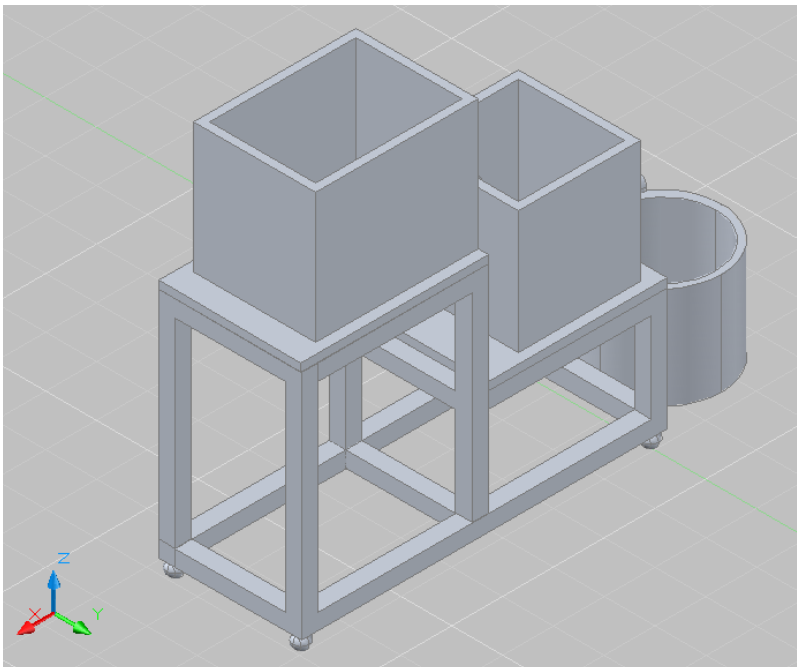
Southwest Isometric View



Southeast Isometric View



Northwest isometric



Northeast Isometric View